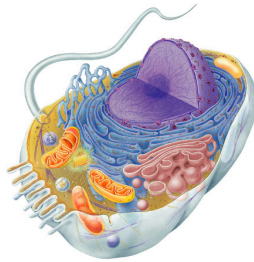


## Chapter 6: Part 2

### Components of the Cells



AP Biology

2005-2006

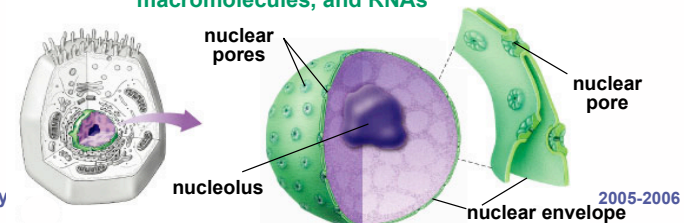
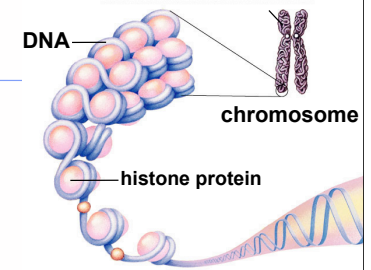
## Nucleus

### Function

- House & protects genetic instructions (**DNA**)

### Structure

- nuclear envelope**
  - double membrane - 2 bilayers!
  - membrane fused in spots to create **pores**
    - Each pore is ringed by proteins = **Pore Complex**
      - Regulates entry and exit of most proteins, macromolecules, and RNAs



AP Biology

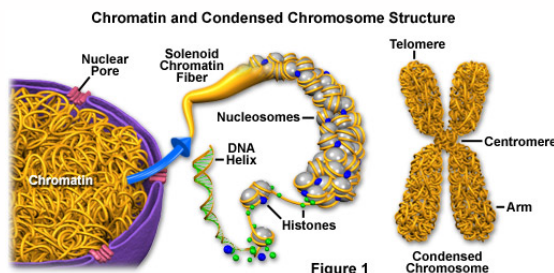
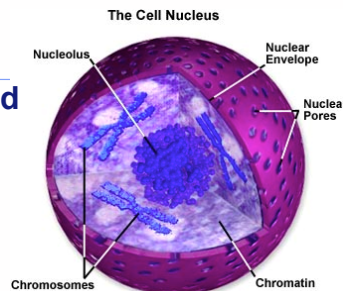
2005-2006

## Nucleus structure

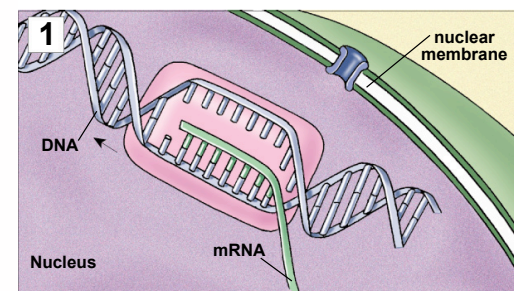
- Within nucleus, DNA organized into fibrous material, **chromatin** (DNA wrapped around histone proteins)

- in normal cell appears as diffuse mass

- When cell prepares to divide, chromatin fibers coil up as separate structures called **chromosomes**

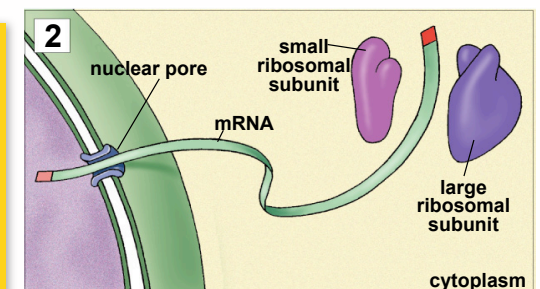


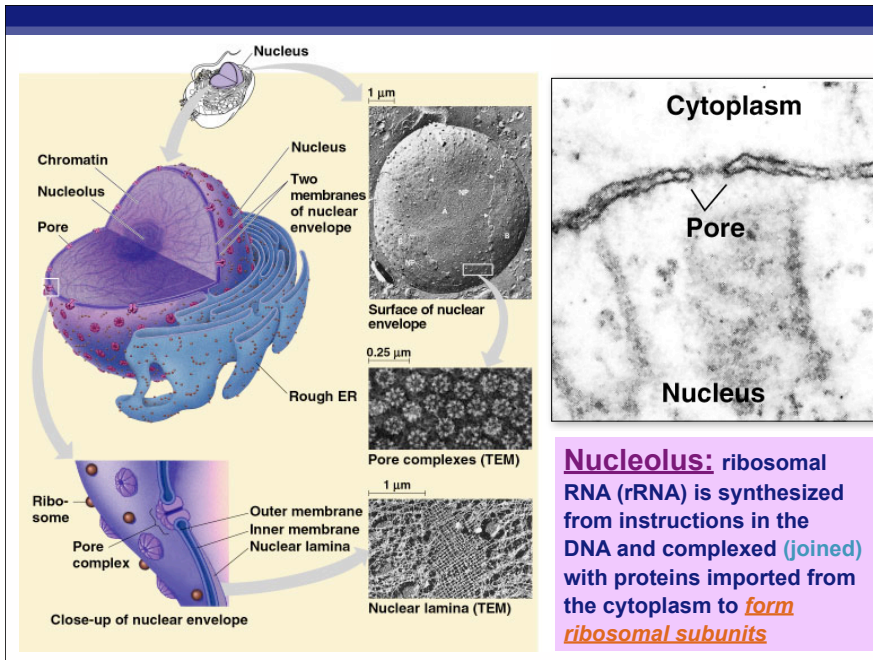
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**DNA does not leave the Nucleus. Messenger RNA (mRNA) is produced from DNA in the nucleus to carry instructions to the cytoplasm**

**mRNA travels from nucleus to ribosome in cytoplasm through nuclear pore where mRNA can be translated into the primary amino acid sequence of a polypeptide as specified in the DNA**





## Nucleolus

- Function
  - ribosome subunit production**
    - build ribosome subunits from rRNA & proteins
    - Ribosomal subunits exit through the nuclear pores to the cytoplasm & combine when necessary to form functional **ribosomes**

The 3D model shows the large and small subunits of a ribosome, composed of rRNA and proteins. The electron micrograph shows a nucleolus within a nucleus, with a label pointing to the nucleolus.

## Ribosomes

- The genes for rRNA have the greatest commonality among all living things (the DNA sequences are highly conserved).
  - There is very little difference in the DNA sequence of the rRNA genes in prokaryotes and eukaryotes.
  - Building of a ribosome is so integral to life that every cell does it almost exactly the same way.
- Function
  - protein production (synthesis)**
- Structure
  - Each subunit contains rRNA & protein
  - 2 subunits combine

The diagram shows a cell with ribosomes and the rough endoplasmic reticulum (ER). The electron micrograph shows ribosomes at a scale of 0.08 µm. Labels include Ribosomes, Rough ER, and Smooth ER.

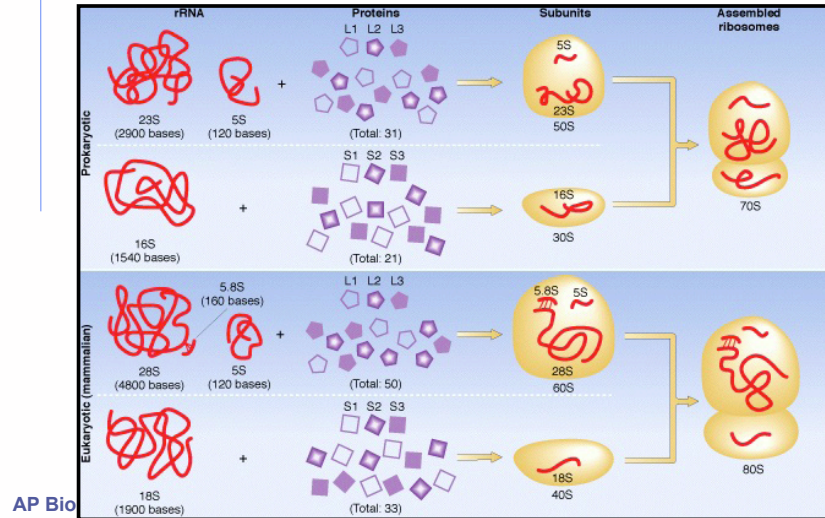
## Ribosomes

- Prokaryotes & eukaryotes have different ribosomes [no ribosome = no protein = death]
  - different size subunits**
  - contain different proteins**
  - can this difference be useful? Yes, we can design drugs to attack a bacteria while not harming our own eukaryotic cells.

The diagram shows the large and small subunits of a prokaryotic ribosome (70 S). The large subunit is 50 S and the small subunit is 30 S. A box highlights that selective poisons can target the proteins of prokaryotic (bacterial) ribosomes = **antibiotics**.

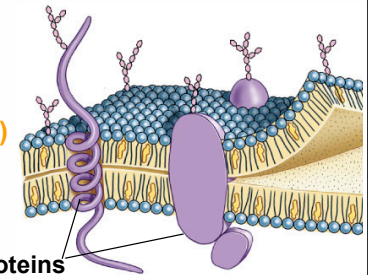
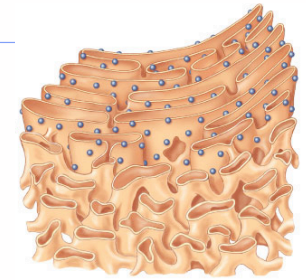


## Prokaryote vs. eukaryote ribosomes



## Types of Ribosomes

- **Free ribosomes**
  - ◆ suspended in cytosol
  - ◆ synthesize proteins that function in cytosol
- **Bound ribosomes**
  - ◆ Though they start off as free ribosomes, they later attach to exterior of **endoplasmic reticulum or nucleus**
  - ◆ synthesize proteins for **export**, for use in the membrane or lumen (interior) of some organelles, the organelles that make up the **endomembrane system**.



AP Biology

membrane proteins

## Endoplasmic Reticulum

- extensive network of membranes

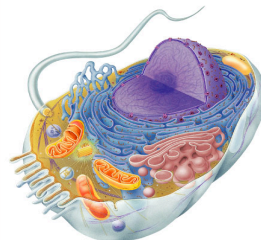
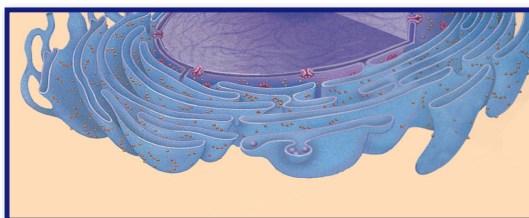
### Function

- ◆ Detox toxins
- ◆ Process certain proteins
- ◆ Regulate protein traffic
- ◆ Participate in metabolic functions

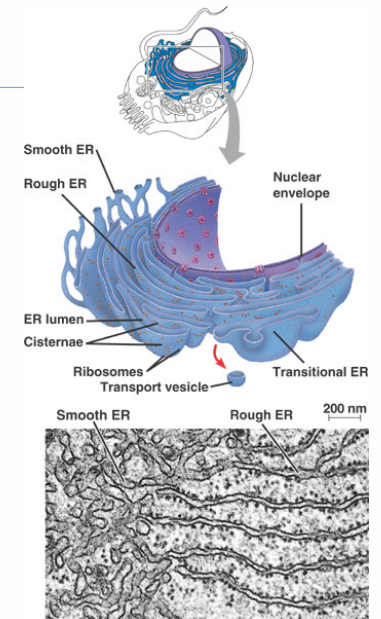
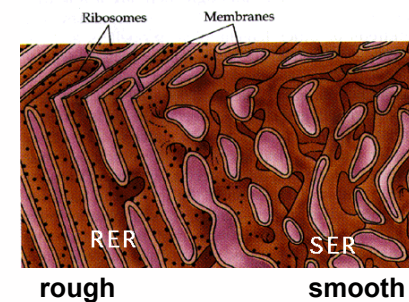
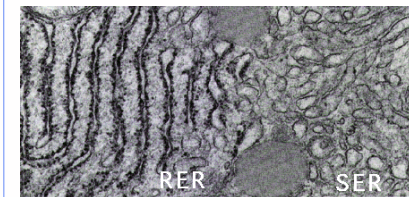
### Structure

- ◆ Network of tubules and sacs called **cisternae**
- ◆ Internal cavity is called the ER lumen or **cisternal space**
- ◆ Membrane is continuous with that of the nuclear envelope & extends throughout cell

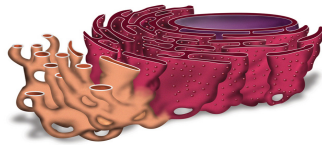
**Endomembrane System:**  
 Nuclear Envelope,  
 Endoplasmic Reticulum,  
 Golgi Apparatus, Lysosomes,  
 Vacuoles, Vesicles, plasma  
 membrane



## Types of ER: Smooth & Rough



## Smooth ER function



### Synthesis of lipids

- oils, phospholipids, steroids & sex hormones

### Detoxification of drugs & poisons

- Involves adding -OH to increase solubility so drugs can be removed from the body
  - High amount of SER found in the cells of the liver
  - Ex: alcohol & barbiturates [depressants]
- Cell may respond to high exposure by increasing SER and its enzymes, which then increases tolerance of the organism to the drug, can increase tolerance to other drugs, or decreases effectiveness of medications over time



### Metabolism of carbohydrates

- Synthesize and later hydrolyze glycogen into glucose
  - Again, this happens mostly in liver cells

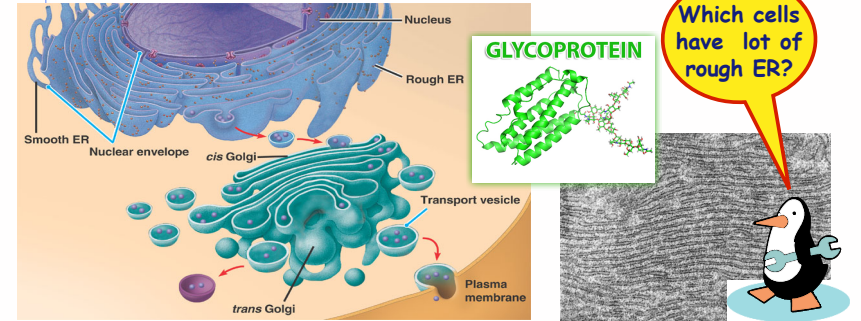
### Storage

- Ex: Calcium ions are stored in SER in skeletal muscles, which are ions needed for muscle contractions.



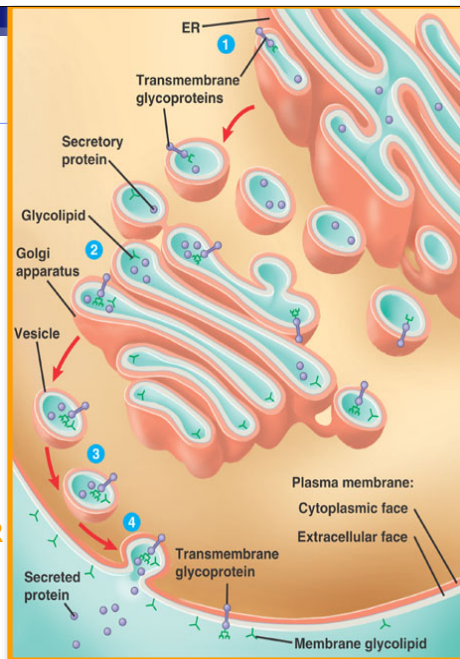
## Rough ER function

- Produce proteins for export out of cell or inclusion in the plasma membrane or endomembrane organelles
  - High amount found in protein **secreting** cells
  - Proteins are packaged into **transport vesicles** that bud off of the RER
- Membrane supply for the cell's endomembrane organelles
- Proteins might be glycosylated [attach oligosaccharides to protein R groups to **make glycoproteins**]



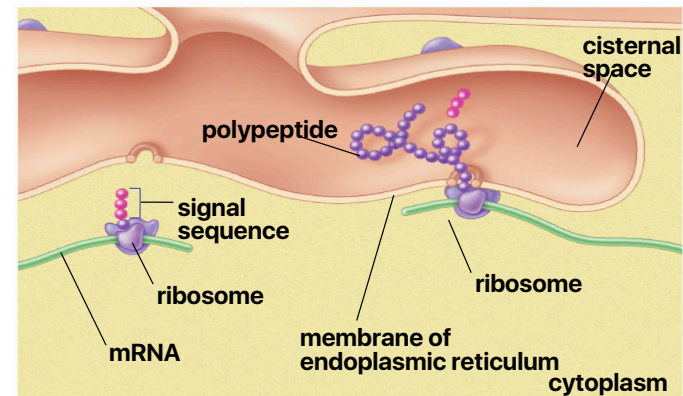
## Protein Processing

- Polypeptides destined for secretion or plasma membrane are fed into RER through pores as they are made by ribosomes on the outer surface of RER.
- Polypeptides fold into proper shapes either inside the lumen of the RER or embedded in the membrane of the RER
- Carbohydrate moieties can be attached in the RER by RER membrane proteins.



## Synthesizing proteins for secretion or endomembrane use.

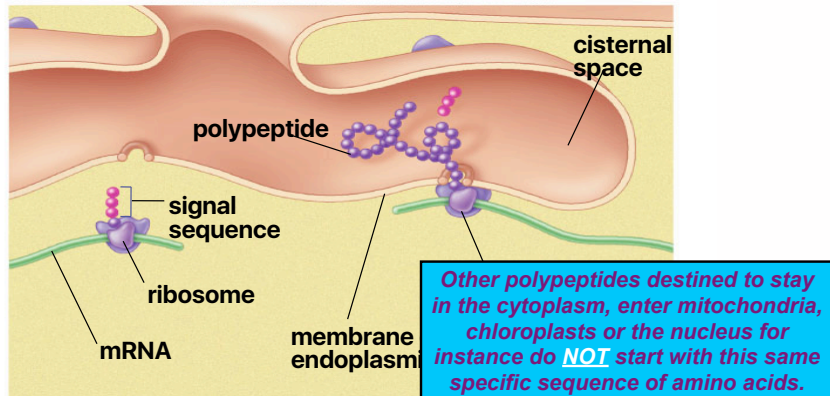
- The DNA's message, copied into mRNA, tells the ribosomes which amino acids to attach in what order when building a polypeptide.





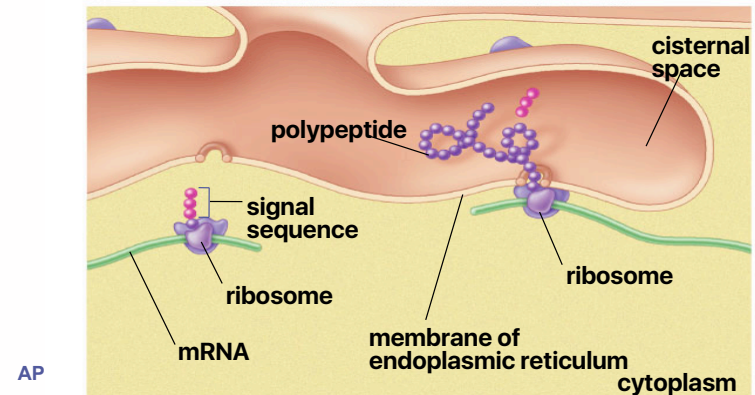
## Synthesizing proteins for secretion or endomembrane use.

- Polypeptides that are destined for the RER are built with a specific initial short sequence of amino acids called the **Signal Sequence**.



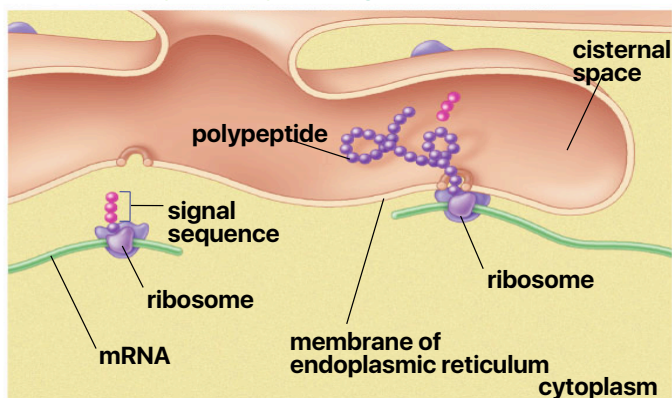
## Synthesizing proteins for secretion or endomembrane use.

- The **Signal Sequence** is recognized by cytosolic proteins, which attract themselves to the growing polypeptide. *These proteins also are attracted to the proteins in the membrane of the RER, which make up the pore complex.*



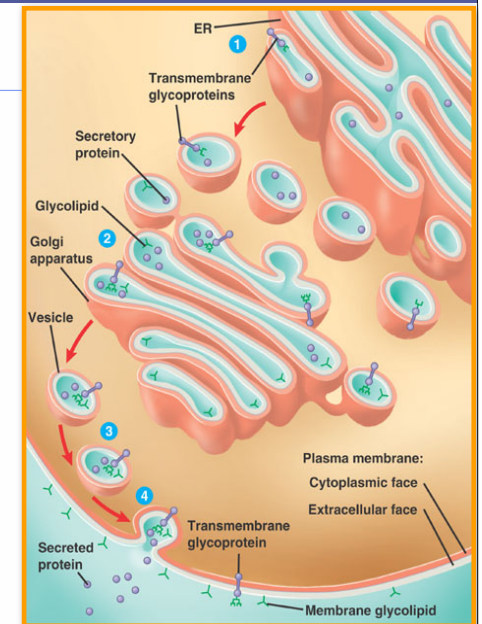
## Synthesizing proteins for secretion or endomembrane use.

- In this way, the mRNA, ribosome, and growing polypeptide are **pulled to the surface of the RER** so the growing polypeptide can be **fed into the RER partially or fully** through the RER's pores.



## Membrane Factory

- The RER is able to build new membrane for the cell
  - It can synthesize its own phospholipids
  - ER membrane expands by adding phospholipids and membrane proteins to its own existing membrane
    - This membrane can bud off & transfer to other endomembrane parts of cell that need membranes including the plasma membrane



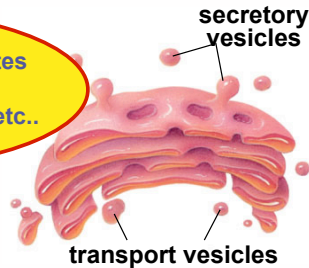
# Golgi Apparatus

- Composed of membrane sacs called **cisternae**
- Function**
  - Modifies, stores, sorts, & ships the cell's ER protein and glycoprotein products**
    - like "UPS shipping department"
    - Ex: may add phosphate groups to certain sugars of glycoproteins
  - Produces certain macromolecules including carbohydrates like non-cellulose polysaccharides**
    - Ships products in **vesicles**

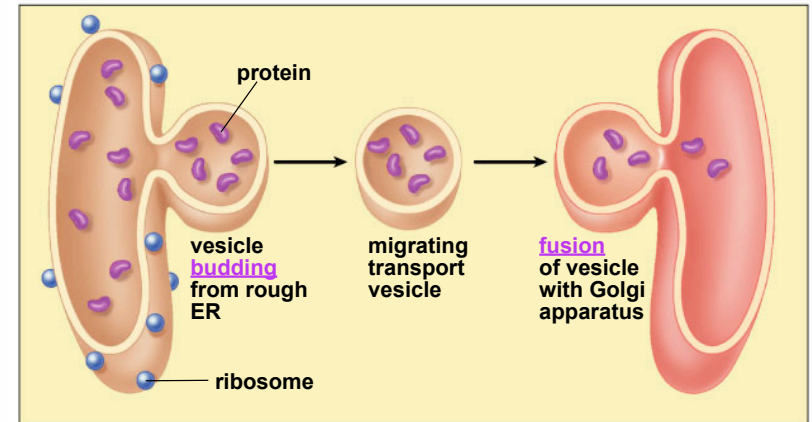


Which cells have lots of Golgi?

**endocrine glands:**  
produce hormones. Ex: testes  
**exocrine glands:**  
produce digestive enzymes etc..  
Ex:



# Vesicle transport



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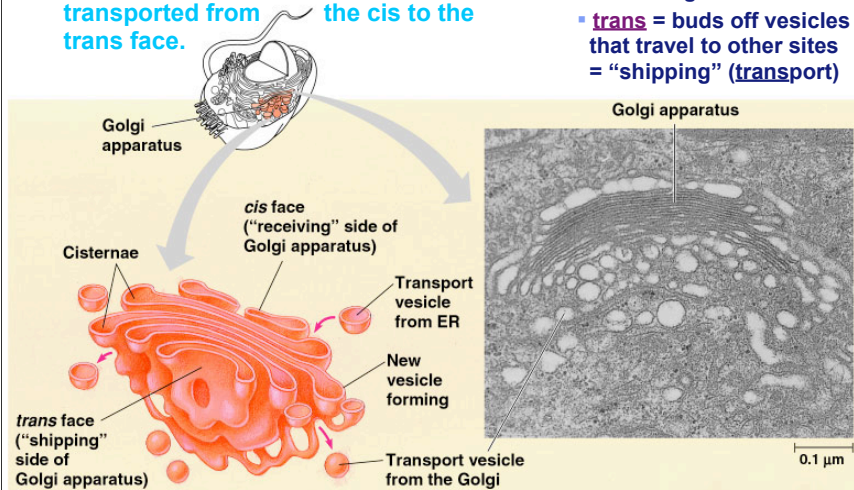
2005-2006

# Golgi Apparatus

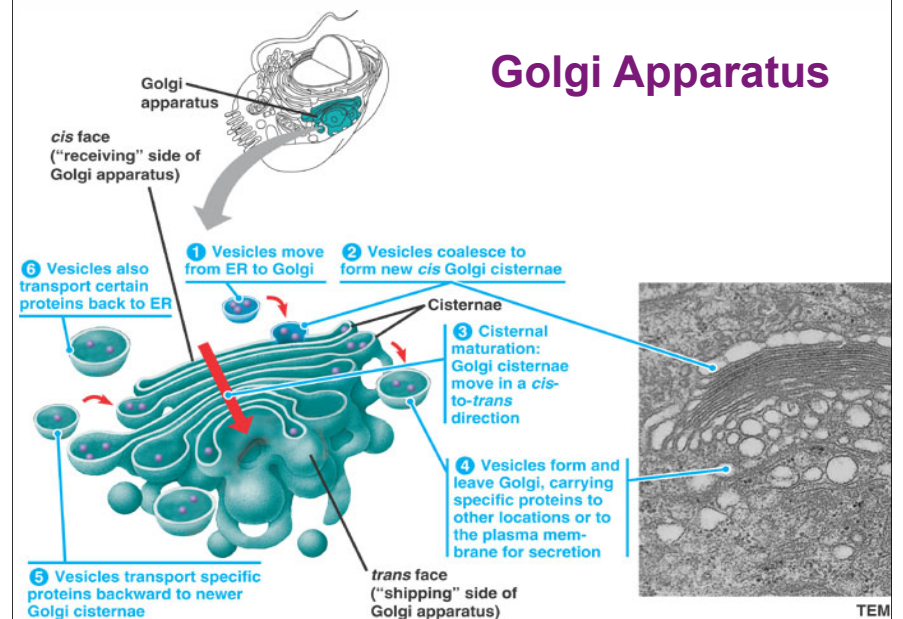
Products are modified as they are transported from the cis to the trans face.

## 2 sides = 2 functions

- cis** = receives material by fusing with vesicles = "receiving"
- trans** = buds off vesicles that travel to other sites = "shipping" (transport)



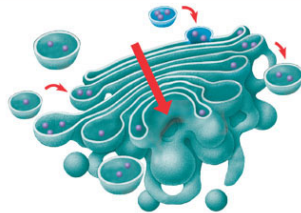
# Golgi Apparatus





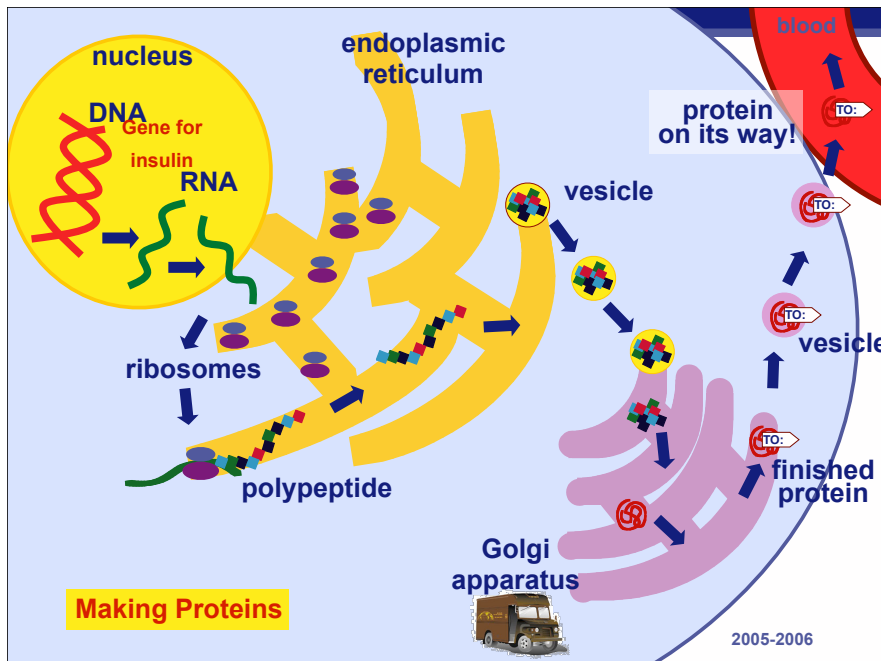
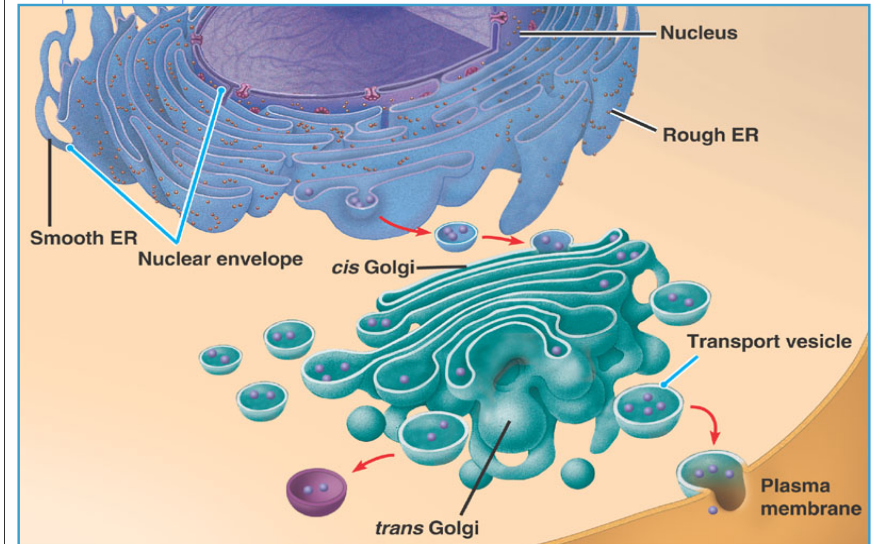
## Golgi processing

- During path from cis to trans, protein/glycoprotein products from ER are modified physically or chemically into final form
- Tags, sorts, & packages materials into transport vesicles
  - ◆ Transport vesicles deliver packages to the parts of the cell that need the carbohydrate or protein products
    - Transport seems to occur by moving the vesicle along microtubules using motor proteins
  - ◆ Vesicles recognize protein docking sites on the surface of other organelles or plasma membrane



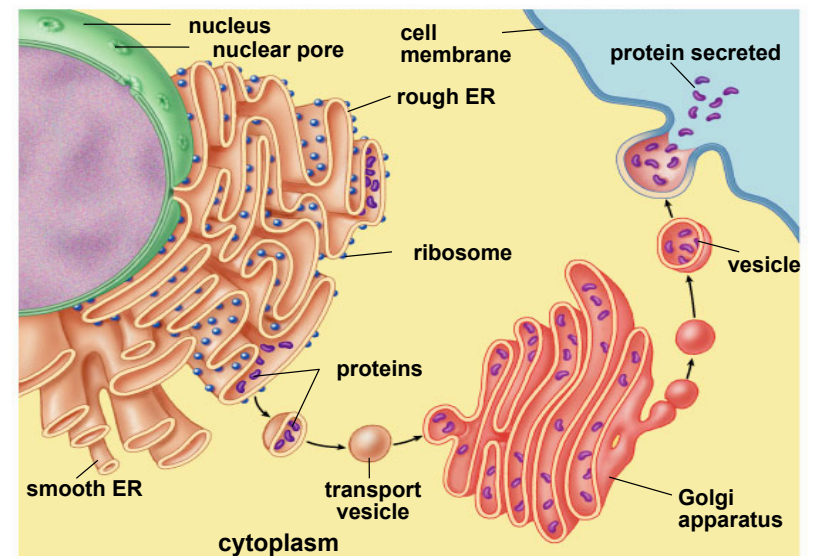
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## Putting it together...



## Putting it together...

Making secretory or plasma membrane proteins

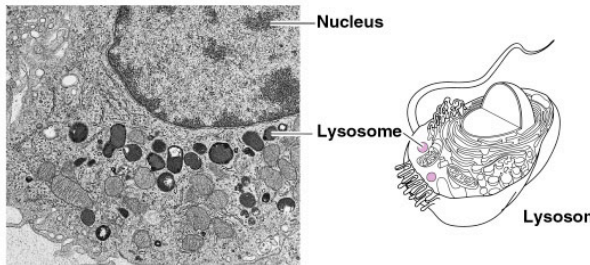


# Lysosomes - “digestive” organelles

## Structure

- ♦ membrane-bounded sac of hydrolytic enzymes that digests macromolecules (i.e. proteases, lipases, nucleases etc..)
- enzymes & membrane of lysosomes are synthesized by rough ER & transferred to the Golgi
  - ♦ Lysosome arises by budding of Golgi's trans face

Only found in animal cells



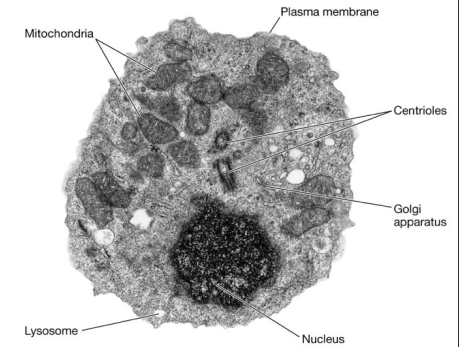
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# Lysosomes

1960 | 1974

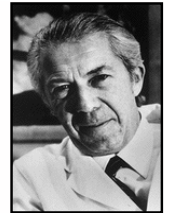
## Function

- ♦ a little “stomach” for the cell
  - lyso- = breaking things apart
  - -some = body
- ♦ they are the “clean up crew” of the cell



Why was this discovery so important?

1974 Nobel prize: Christian de Duve  
Lysosomes discovery in 1960s

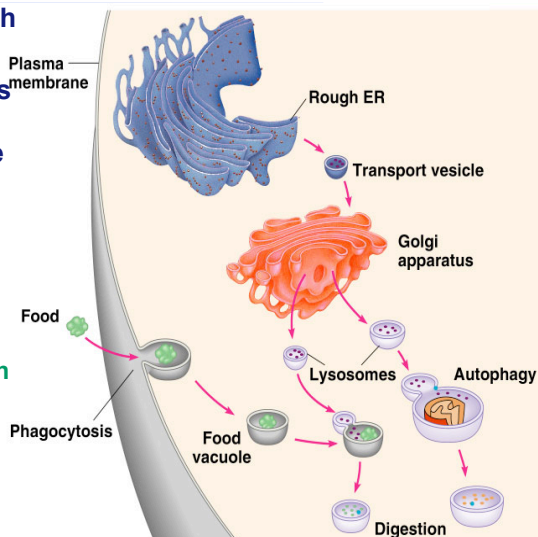


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# Cellular digestion & recycling

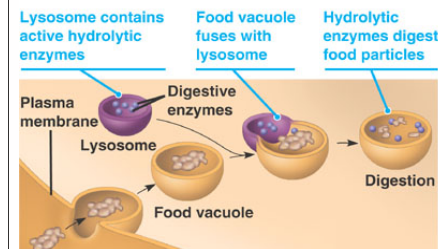
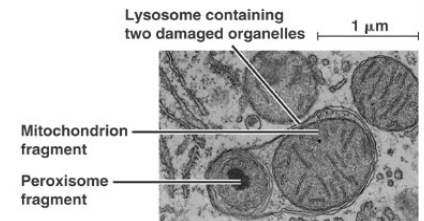
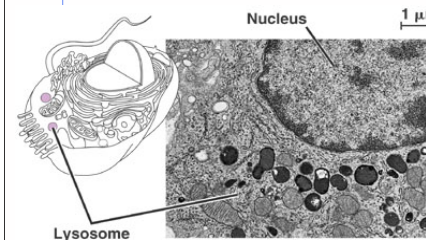
- Lysosomes fuse with food vacuoles
- Fuse with organelles or macromolecules in cytosol to recycle materials

- ♦ Polymers are digested (hydrolyzed - using water) into monomers
- ♦ Monomers are then passed to cytosol to become nutrients of cell

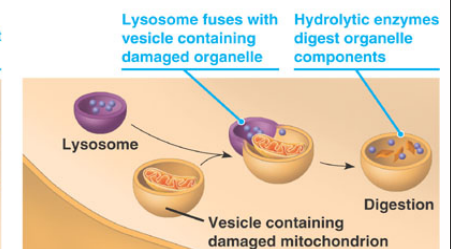


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# Phagocytosis versus Autophagy



(a) Phagocytosis: lysosome digesting food



(b) Autophagy: lysosome breaking down damaged organelle



## Lysosomal enzymes

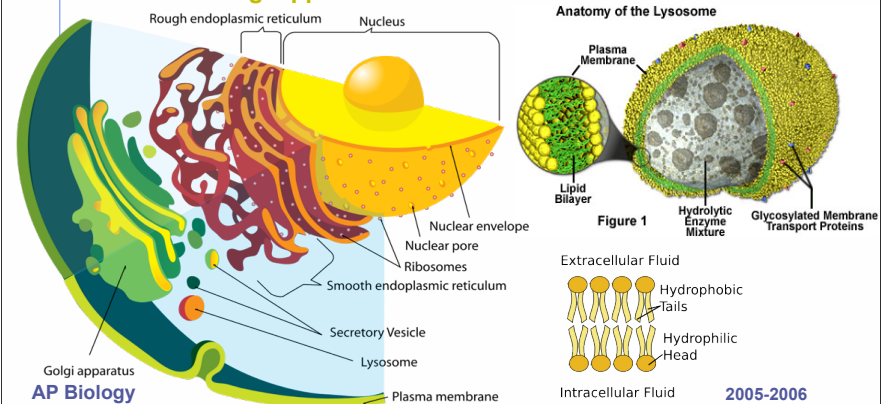
- **Lysosomal enzymes work best at pH 5**
  - ♦ organelle creates compartment with a custom pH, the optimal environment for the hydrolytic enzymes to have their most perfect shape and, therefore, work at their maximum rate of catalysis
    - Rupturing of many lysosomes can destroy a cell as  $H^+$  will leak into the cytoplasm and change the pH of the cytosol.
- ♦ **How does lysosome maintain low pH environment?**
  - proteins in lysosomal membrane pump  $H^+$  ions from the cytosol into lysosome to change internal pH
- ♦ **Why?**
  - enzymes are very sensitive to pH and pH affects proper structure of digestive enzymes (proteins)
- ♦ **Why evolve digestive enzymes which function at pH different from cytosol?**
  - Don't want to digest yourself! Want hydrolytic proteins only active where and when needed, but not when being made in the RER and Golgi.

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2005-2006

## Lysosomes

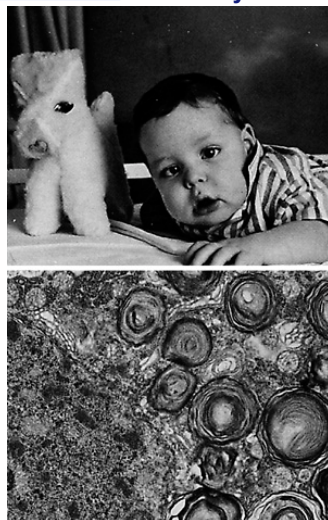
- **Like any cellular membrane...lysosomal membranes are phospholipid bilayers.**
  - ♦ Remember too that lysosomes are made by the pinching off of the Golgi apparatus



## When things go wrong...

Tay-Sachs

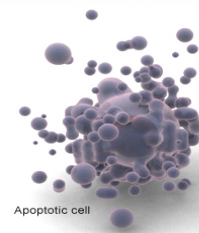
- What if a lysosome digestive enzyme doesn't function?
  - ♦ **Cells can't digest biomolecules**
    - instead biomolecules collect in lysosomes
    - lysosomes fill up with undigested material
  - ♦ **lysosomes grow larger & larger**
    - eventually disrupt cell & organ function
- **"Lysosomal storage diseases" are usually fatal**
  - ♦ **Tay-Sachs disease**
    - lipids build up in brain cells
    - child dies before age 5



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## Sometimes its supposed to work that way...

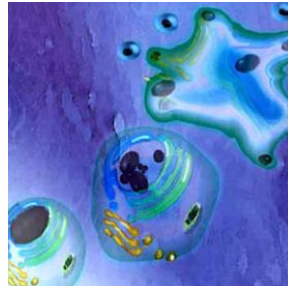
- **Apoptosis = programmed cell death**
  - ♦ critical role in programmed destruction of cells in multi-cellular organisms
    - **auto-destruct mechanism**
      - ♦ "cell suicide"
  - ♦ **Feedback mechanism**
    - There are sensors in the cell that monitor growth & DNA damage.
    - They trigger self-destruct when they sense processes gone awry or when they receive a chemical message to do so



2005-2006

## Sometimes its supposed to work that way...

- some cells have to die in an organized fashion, especially during development
  - ex:** development of space between your fingers during embryonic development
  - ex:** if cell grows improperly this self-destruct mechanism is triggered to remove damaged cell
    - cancer over-rides this to enable tumor growth**
  - ex:** Brown spots on leaves too: Virus infected plant cell auto-destructs and even kills cells around it to wall off virus.



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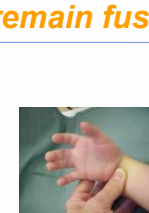
## Fetal development - *when apoptosis fails, digits remain fused* syndactyly



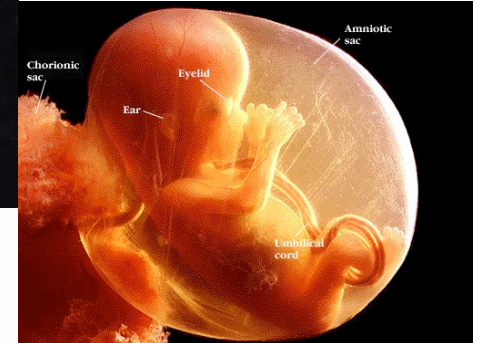
6 weeks



AP



15 weeks



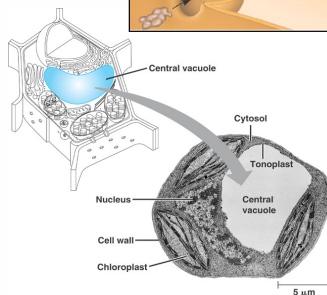
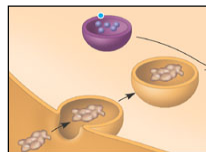
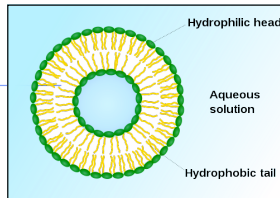
## Vesicles & vacuoles

### Vesicle Function

- little "transfer ships" for transport within the cell

### Vacuoles Function [often larger than vesicles]

- Food vacuoles**
  - Created through phagocytosis. They fuse with lysosomes for digestion in certain protists and animal cells
- Contractile vacuoles**
  - in freshwater protists, pump excess  $H_2O$  out of cell
- Central vacuoles**
  - in many mature plant cells
  - Derived from ER and Golgi
  - Filled with cell sap which has a different functions

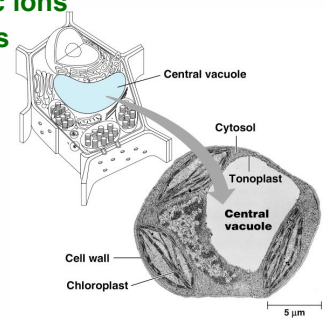
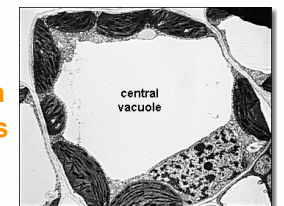


AP Biology

## The Central Vacuole in Plants

### Functions

- Growth**
  - Plays major role in plant cell growth when it absorbs water and expands
- Storage**
  - stockpiling proteins or inorganic ions
  - depositing metabolic byproducts
  - storing pigments
  - storing defensive compounds against herbivores
  - selective membrane
    - control what comes in or goes out



AP Biology



